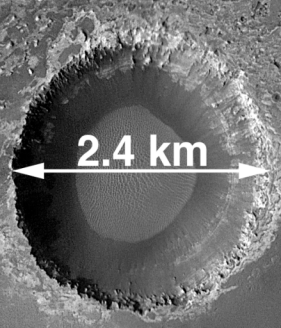
Northern Sinus Meridiani Landing Sites

Ken Edgett and Mike Malin



Acknowledgements

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  - Alfred McEwen and the HiRISE Team (especially for quick turn-around of HiRISE images of candidate sites, acquired Sept/Oct 2007)
  - Sandra Wiseman, Ray Arvidson, and the CRISM Team (for the CRISM data analysis)
  - Jim Bell and Ryan Anderson (for the OMEGA data analysis)
  - Larry Edwards (for CTX stereo, DTM, 3-d rendering work)
  - Bruce Cantor (for Meteorology assistance/experience/prediction)
  - Liliya Posiolova (discussions on northern Meridiani geology)

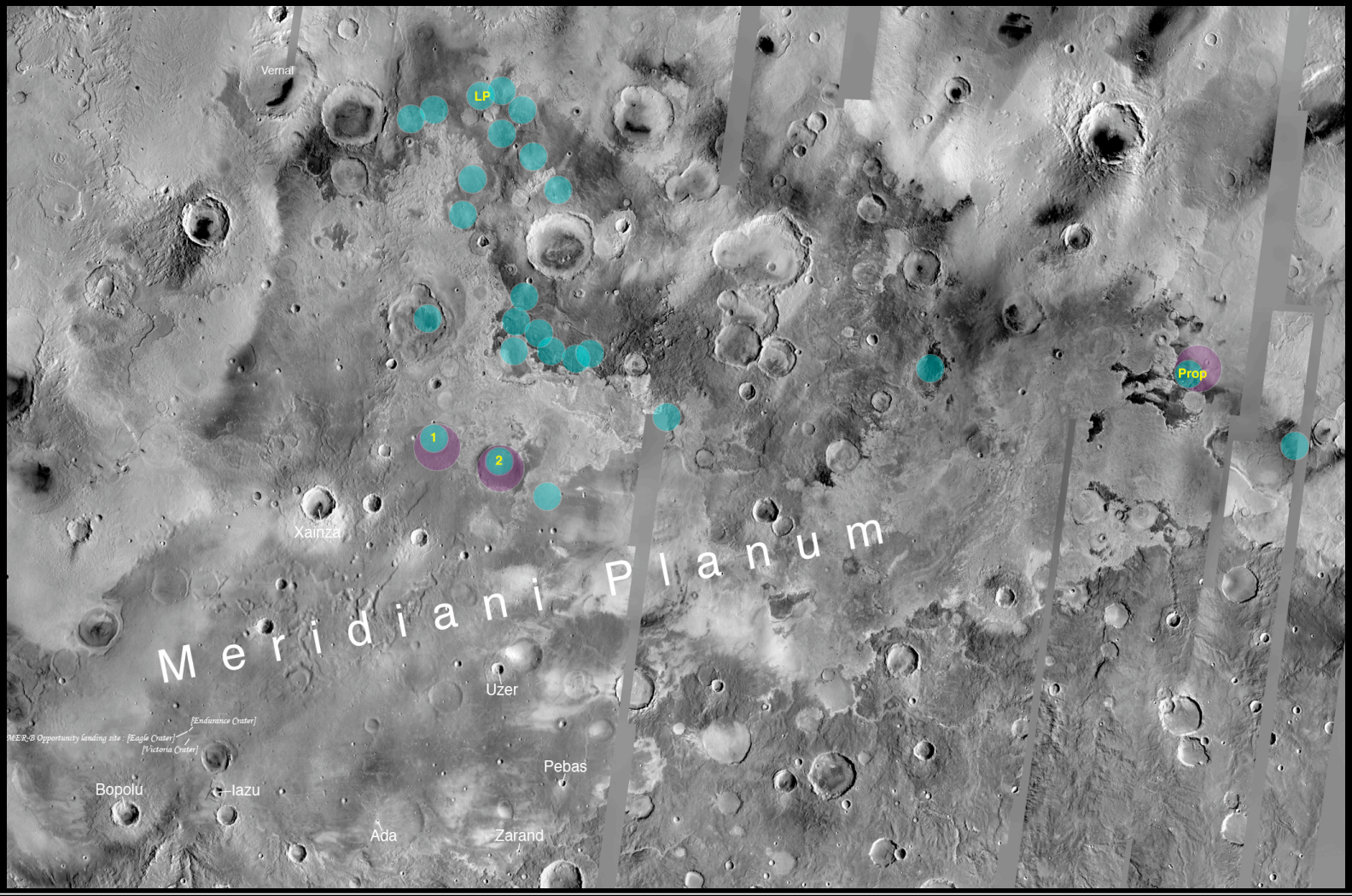
Motivation

- A couple of months ago, we got to thinking… 5 landing sites are going to come out of this workshop for further study. What if all 5 were from the original high science sites that then failed the various tests and we couldn't land at any of them. Where would we suggest to land MsL?
- If MsL were to have no choice but to go to a flat, rock-free, empty plain, almost nowhere on Mars is like this.
- Thus, the only choice would be to go to certain parts of Meridiani Planum— either return to the MER-B site, or go to some very similar areas nearby. We'd rather not return to the MER-B site, or even someplace nearby.
- So, the site we ultimately present here is the product of such a thought process and an effort to find something that looks safe, presents a greater diversity of rocks than at MER-B, and can be explored within the context of testable hypotheses.

Our Objectives were to find a Landing Site that…

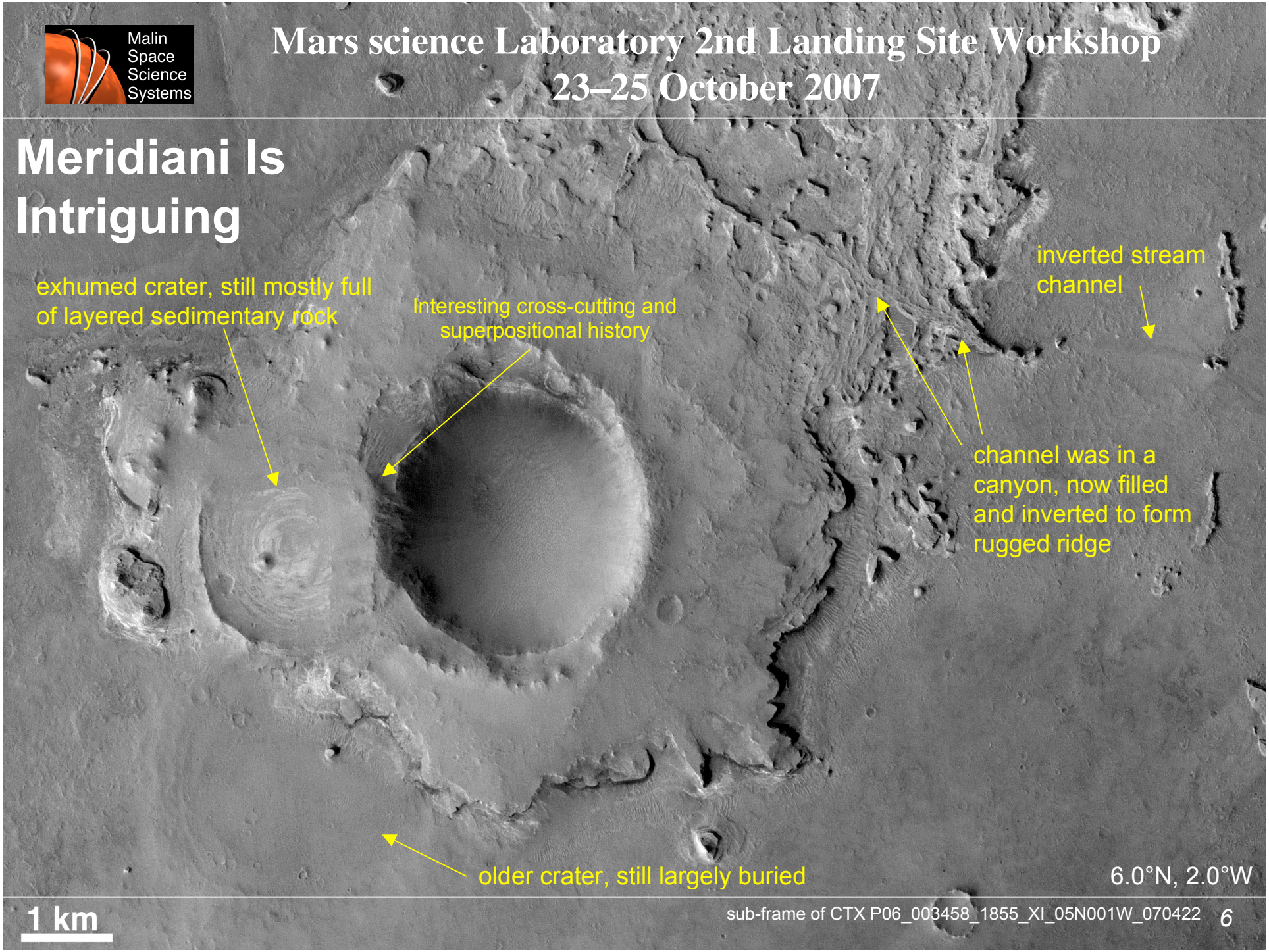
- is as “safe” or nearly as “safe” as the MER-B landing ellipse,
- might include an area large enough for “safe haven” consideration,
- is at a latitude where mission operations will not be slowed by seasonal conditions (e.g., severe winter cold b/c of heating, wet lube, etc.),
- to address “habitability,” presents a diversity of sedimentary rock types (as best as can be known from erosional expression, bedding character, etc.) in or near the ellipse,
- to address “habitability,” presents features attributable to water (regardless of pH) in or near the ellipse, and
- has attributes for which there are hypotheses we can test by going there.

We considered many places in Northern Meridiani



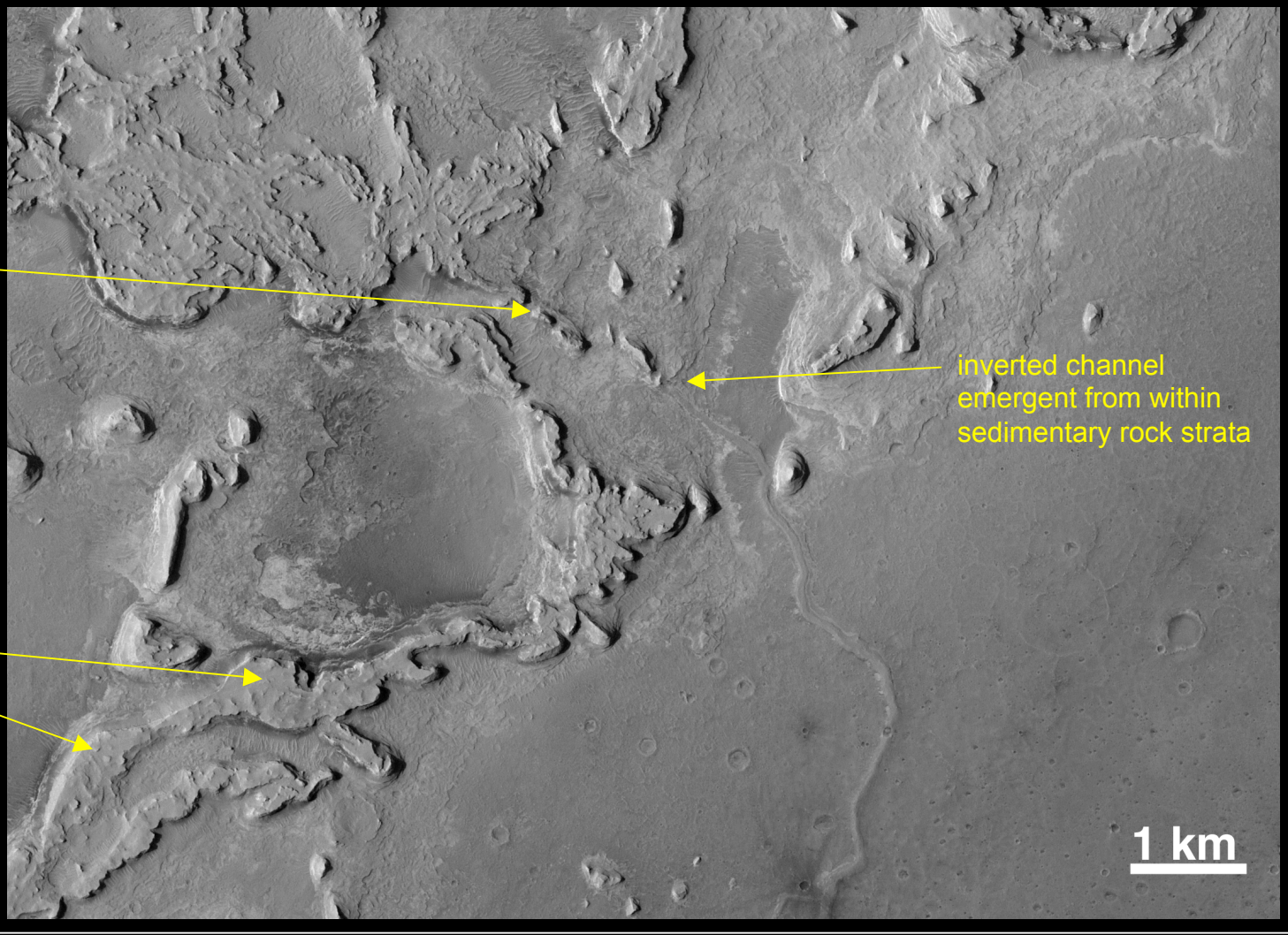
THEMIS IR base map, dn's inverted to simulate albedo pattern.

Meridiani Is Intriguing



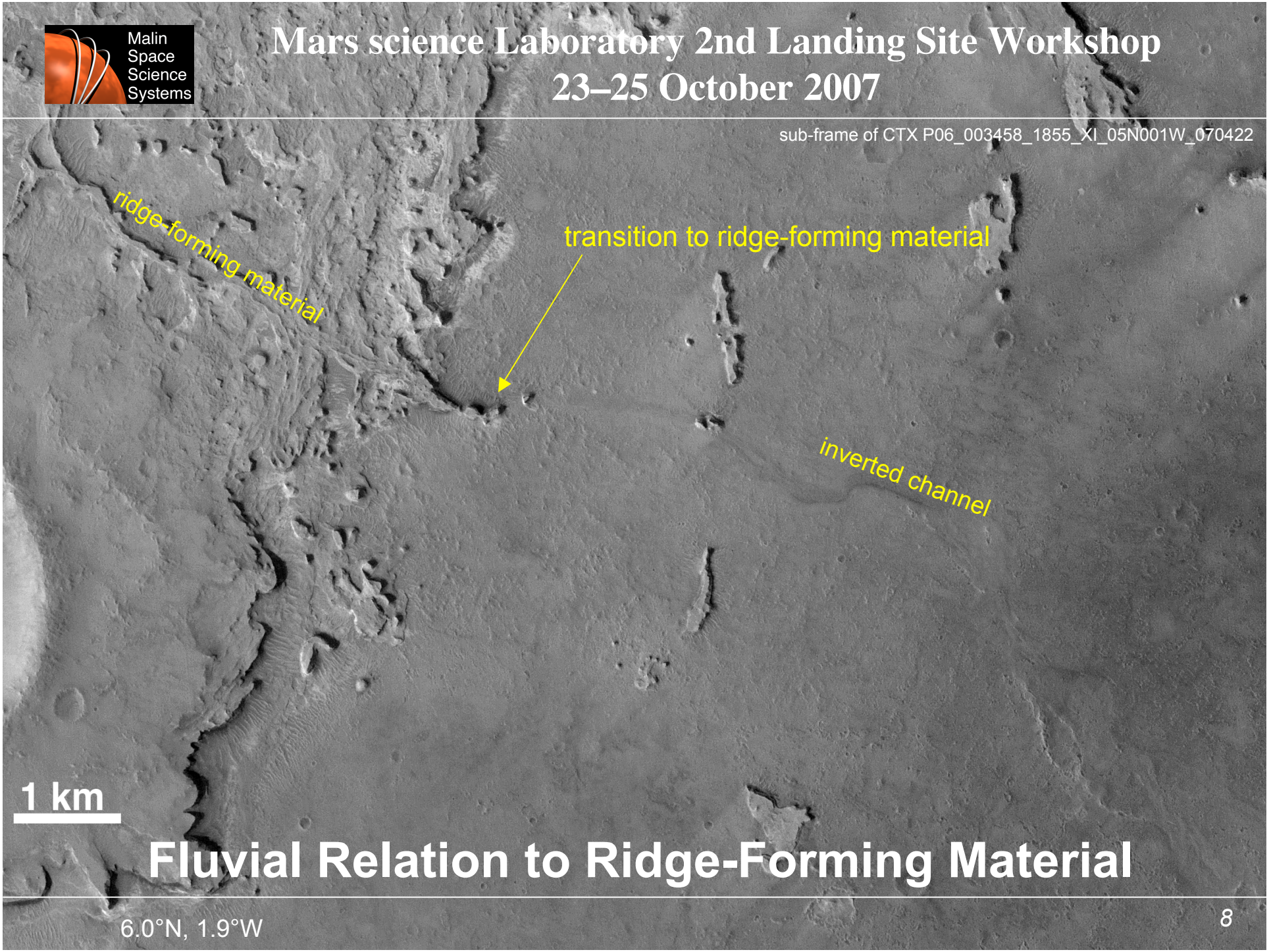
sub-frame of CTX P06_003458_1855_XI_05N001W_070422

A Fluvial Story Emergent from MRO CTX



4.7°N, 1.4°W

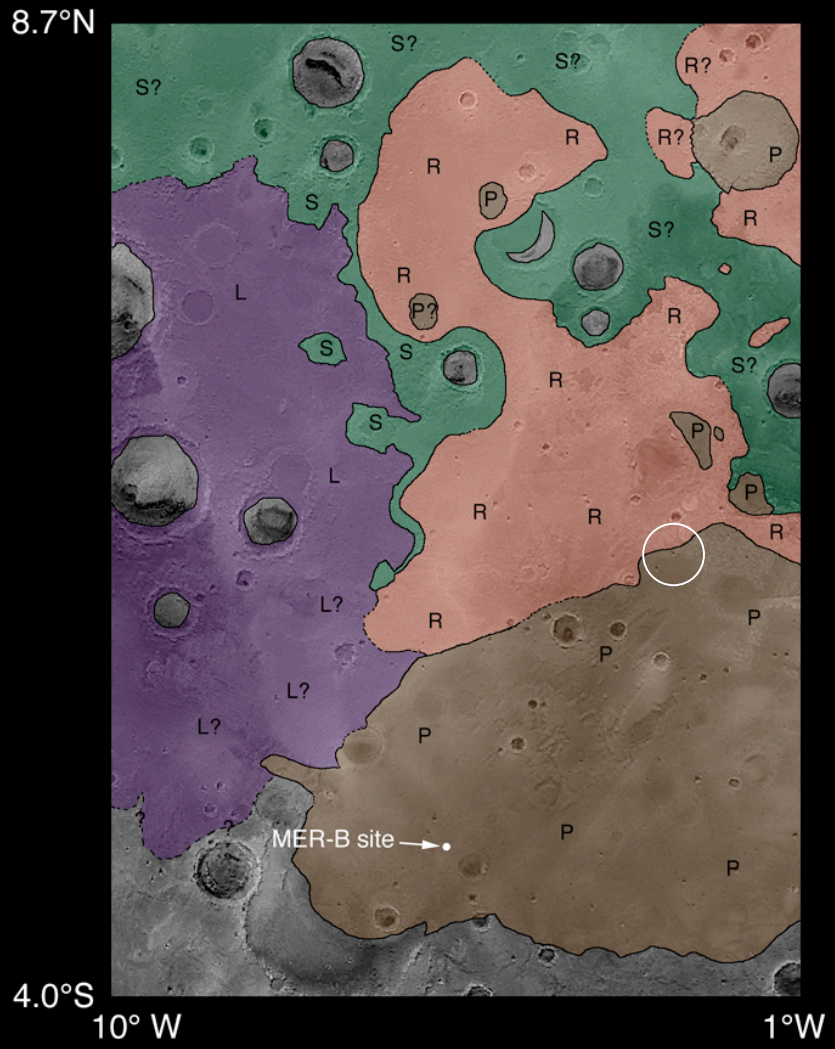
sub-frame of CTX P03_002390_1840_XI_04N001W_070129

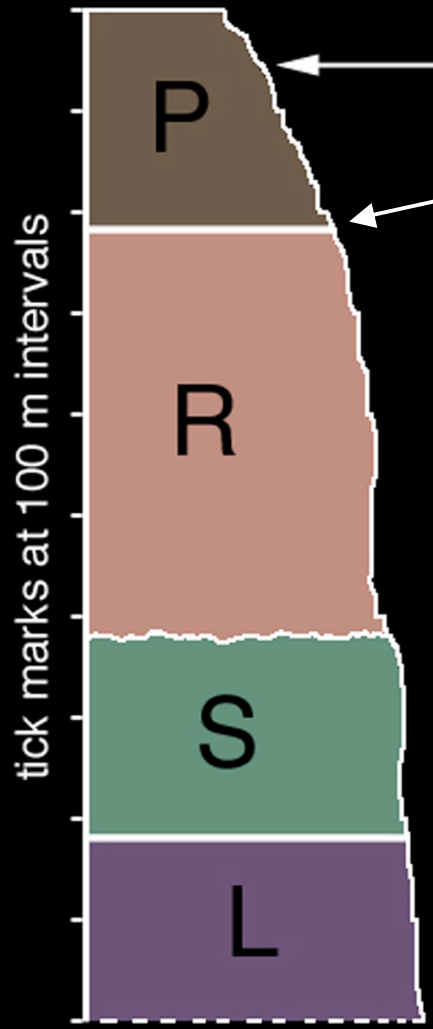


Fluvial Relation to Ridge-Forming Material

6.0°N, 1.9°W

Ridge-Forming Material in Stratigraphic Context





R = Ridge-forming material

- rocks with ridge-forming material are lower in the regional stratigraphic section than rocks at MER-B site.

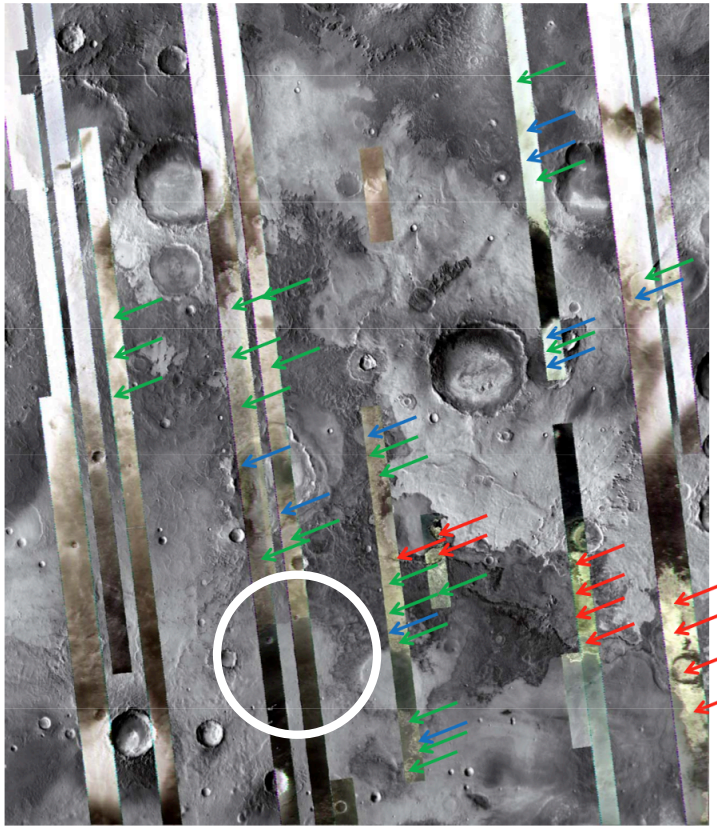
Source: Edgett (2005, *Mars, 1*, 5–58).

Mineralogical Considerations

- OMEGA, CRISM — sulfates, hydrated minerals
- TES — hematite on some of the dark surfaces
- MER-B — various things for which to compare with new landing sites in Meridiani

MER-B Pancam “berry bowl” in Eagle Crater

CRISM 200m/pixel multispectral strips overlain on THEMIS DIR



NOTES
The latest CRISM calibration hasn’t been applied to most CRISM data. Results may change (most likely to include more mineral detections) with newer calibration.

Enhanced Hydration (bound water) Much of the etched terrain has this (in OMEGA data).

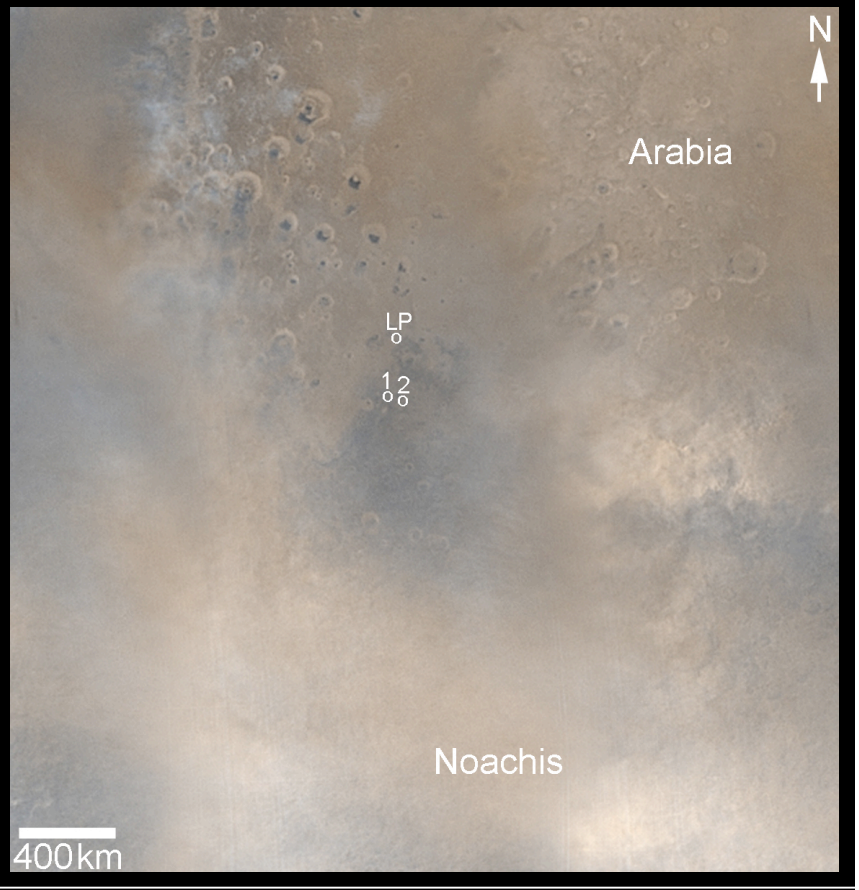
Possible Hydrated Sulfates

Hydrated sulfates

Preliminary CRISM analysis from Sarah Wiseman and Ray Arvidson

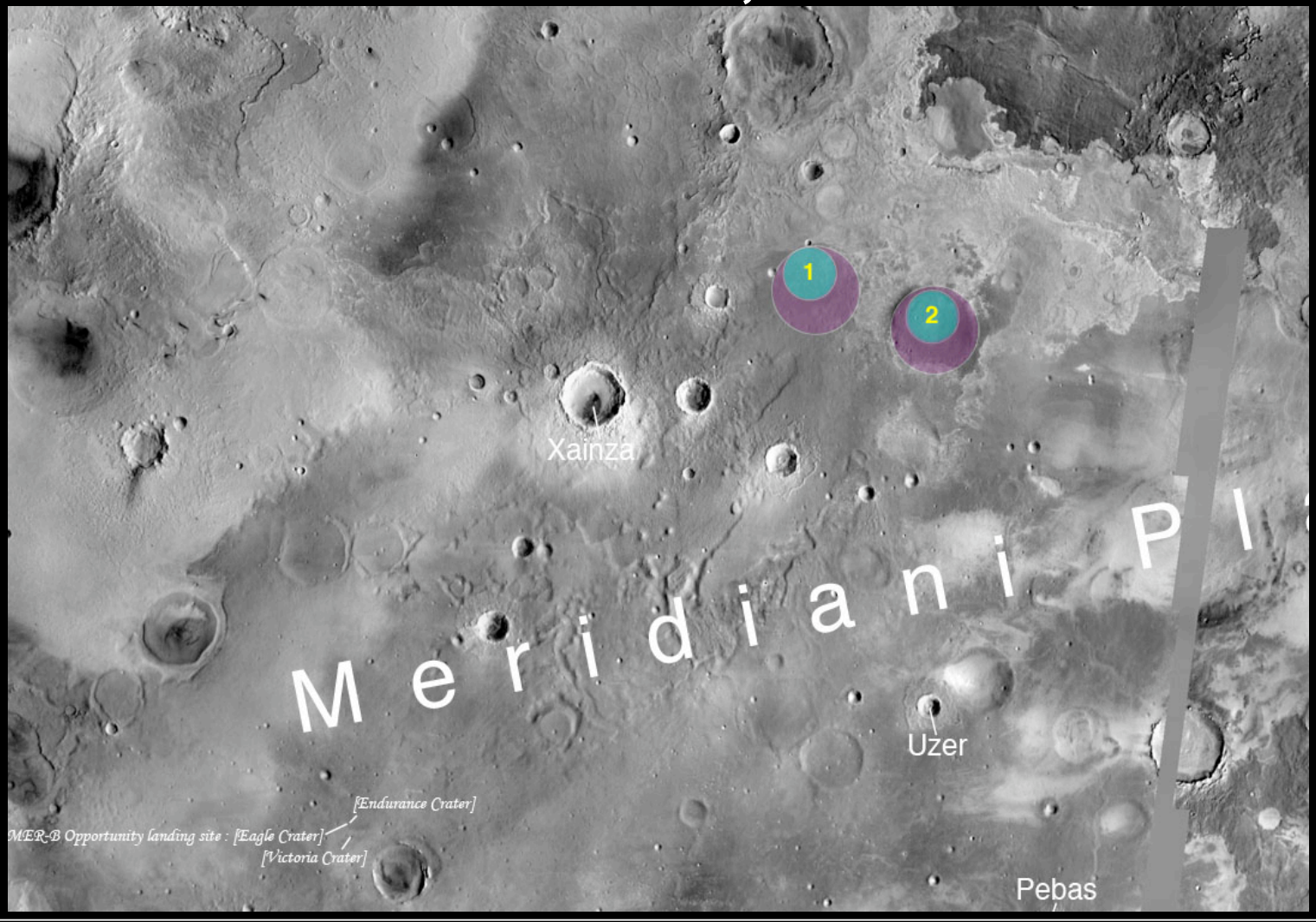
Meteorological Considerations

- Dust storms and dust-raising in Sinus Meridiani is historically unusual.
- We did see some dust-raising *in* Meridiani associated with storm activity in December 2004, and that was the only localized activity for the entire period 1997–2006.
- MsL EDL occurs around L_s 115°–130°. Five Mars years of MOC observations suggest a < 0.7% chance of a dust storm occurring within 15° of lat/lon of northern Meridiani landing sites during EDL.



MGS MOC, Meridiani region, December 2004 storms

Boiled down to 2 sites, with #1 favored

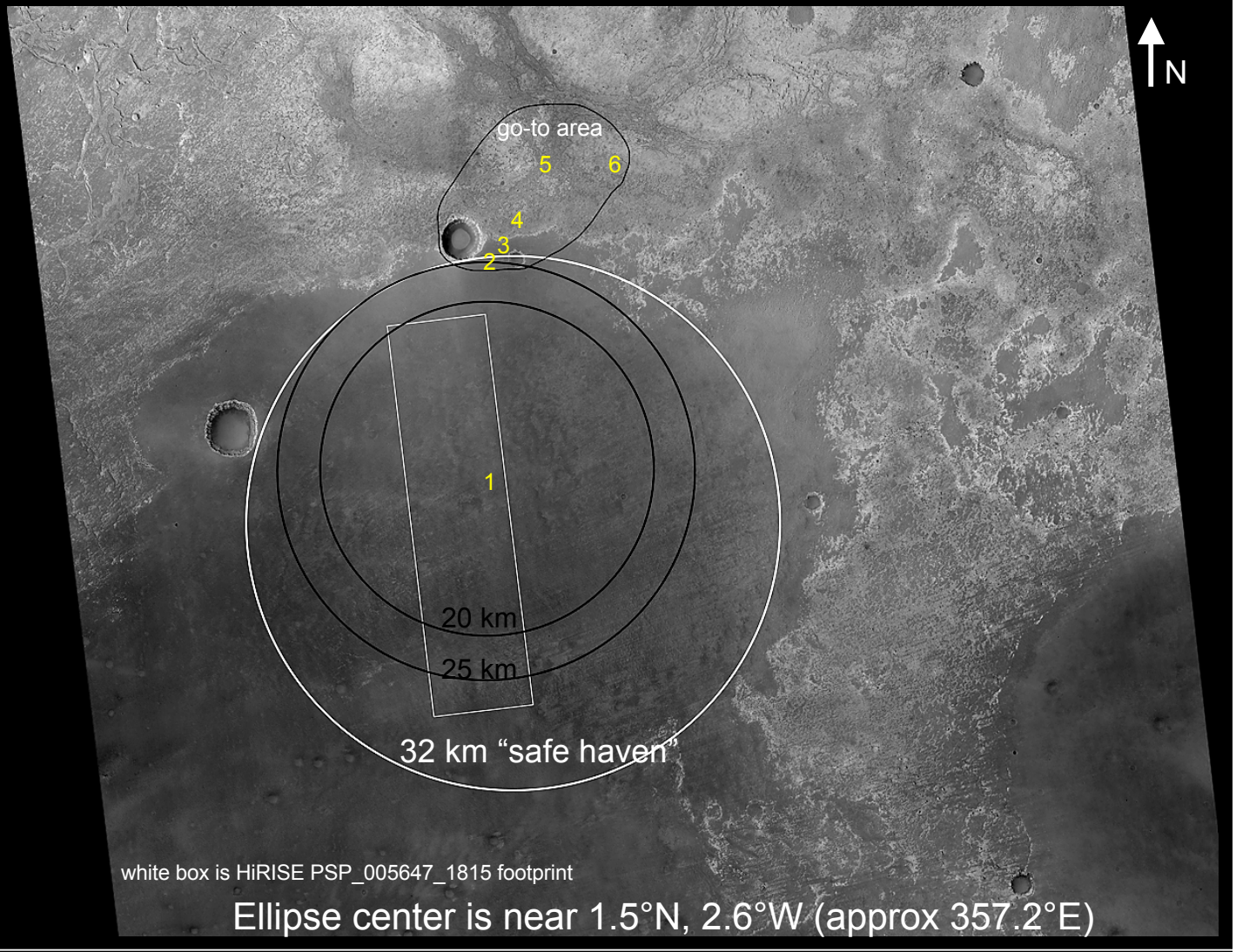


THEMIS daytime IR mosaic, dn's inverted.

Our Recommended North Meridiani Site

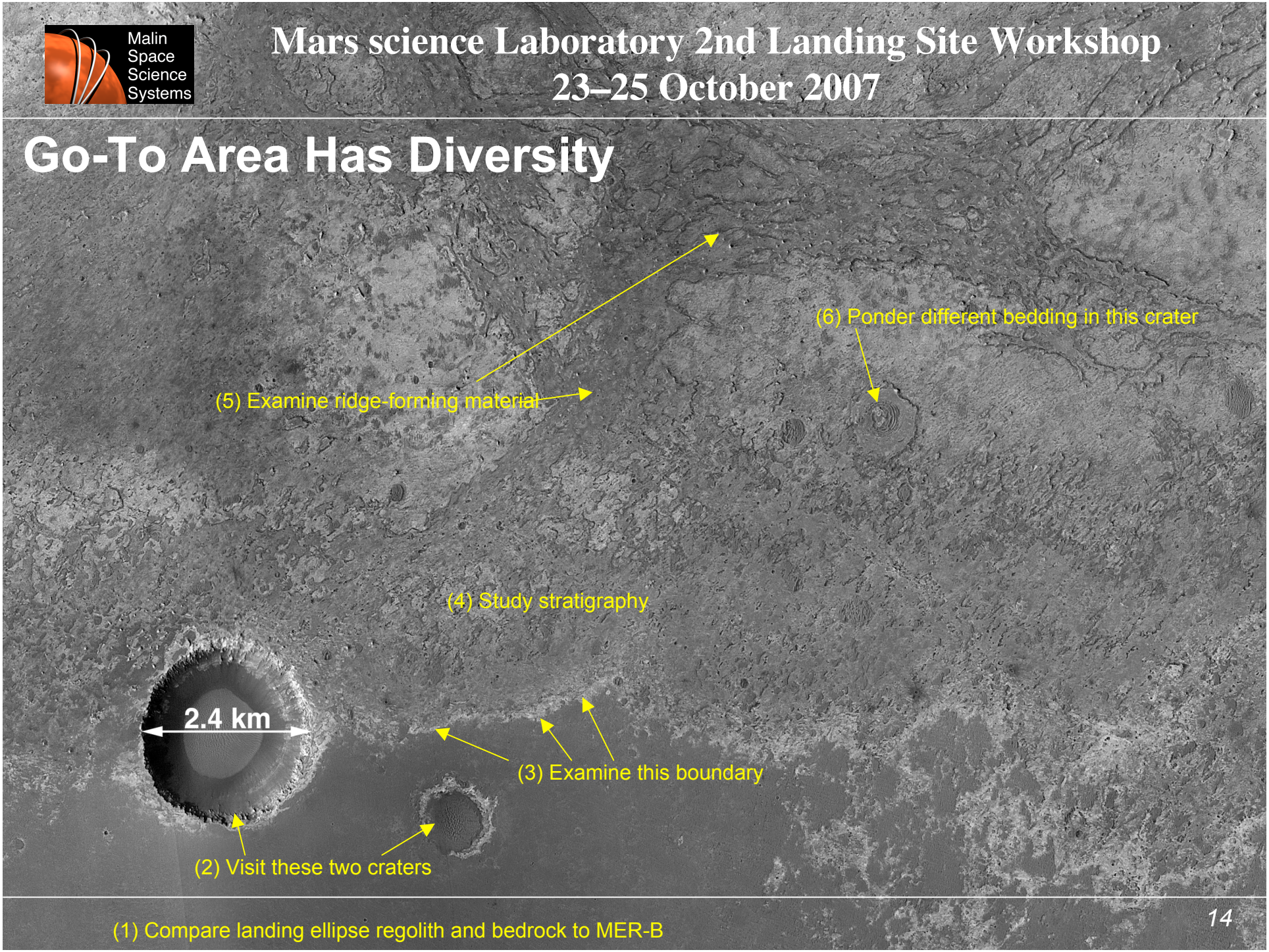
What We Do There:

(1) Examine regolith and bedrock in the ellipse to compare w/ MER-B.
(2) Drive northward to the two craters and examine them.
(3) Drive north between the two craters and examine contact between dark surface and lighter-toned rock surface. MSL is now traveling downward in the stratigraphic section.
(4) Examine strata going northward, downward in section.
(5) Examine ridge-forming material; in some areas these might be fluvial channel fill material. Test that hypothesis.
(6) Drive to an exhumed crater filled with layered strata that are different from anything else thus far examined.

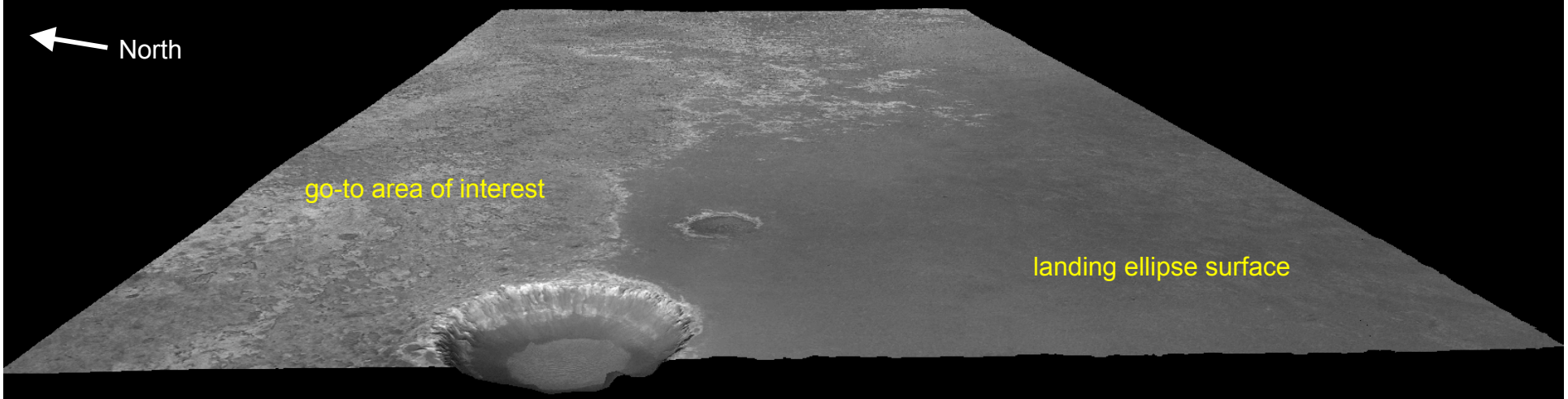


Mosaic of CTX P04_002746_1808_XI_00N002W_070226, P05_003168_1825_XI_02N002W_070331, P06_003379_1827_XN_02N002W_070416

Go-To Area Has Diversity



The Terrain is “Pretty Flat”

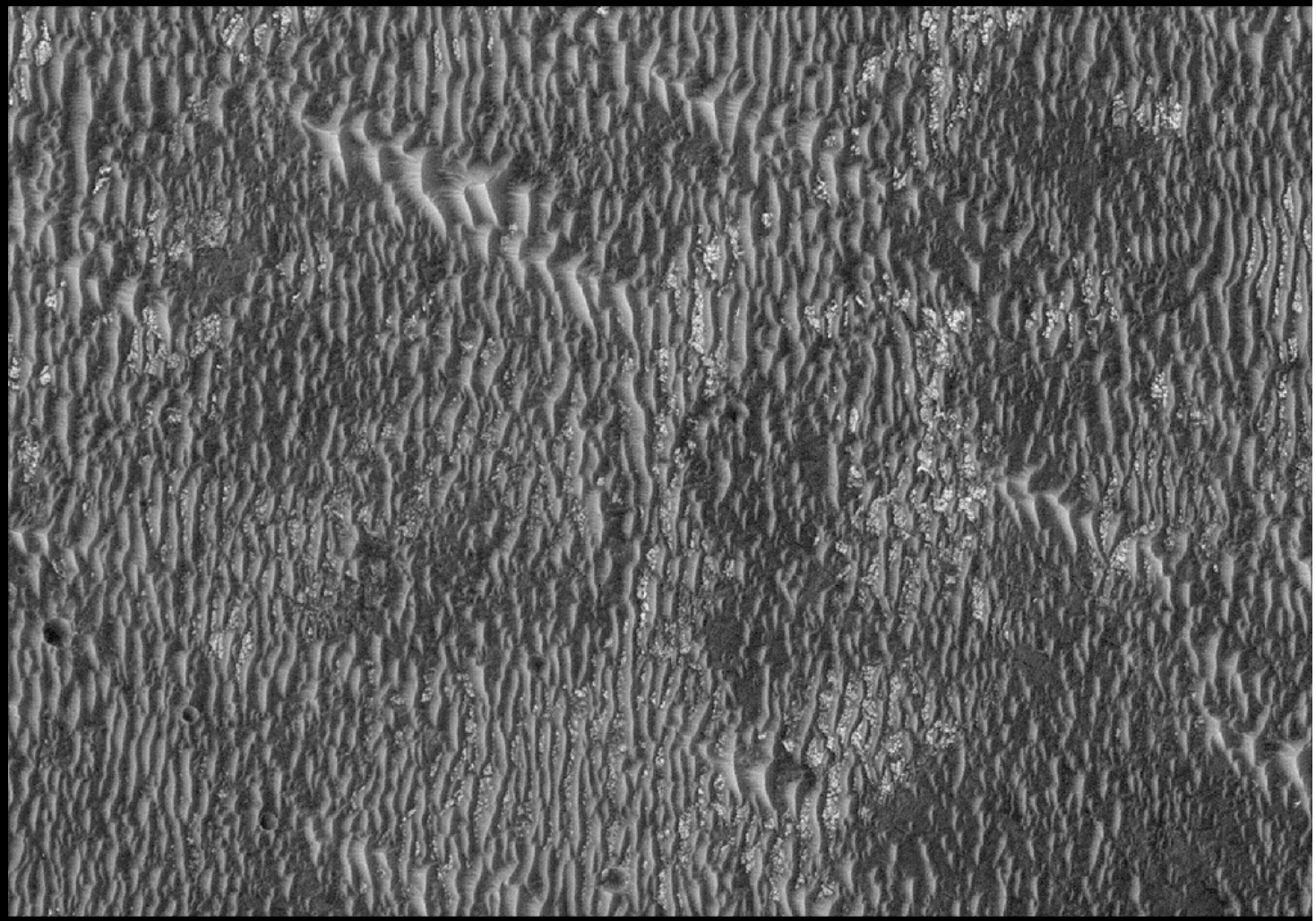


large crater is ~2.4 km wide and ~750 m deep

based on DTM created from CTX stereo by Larry Edwards

(1) Landing Ellipse Surface

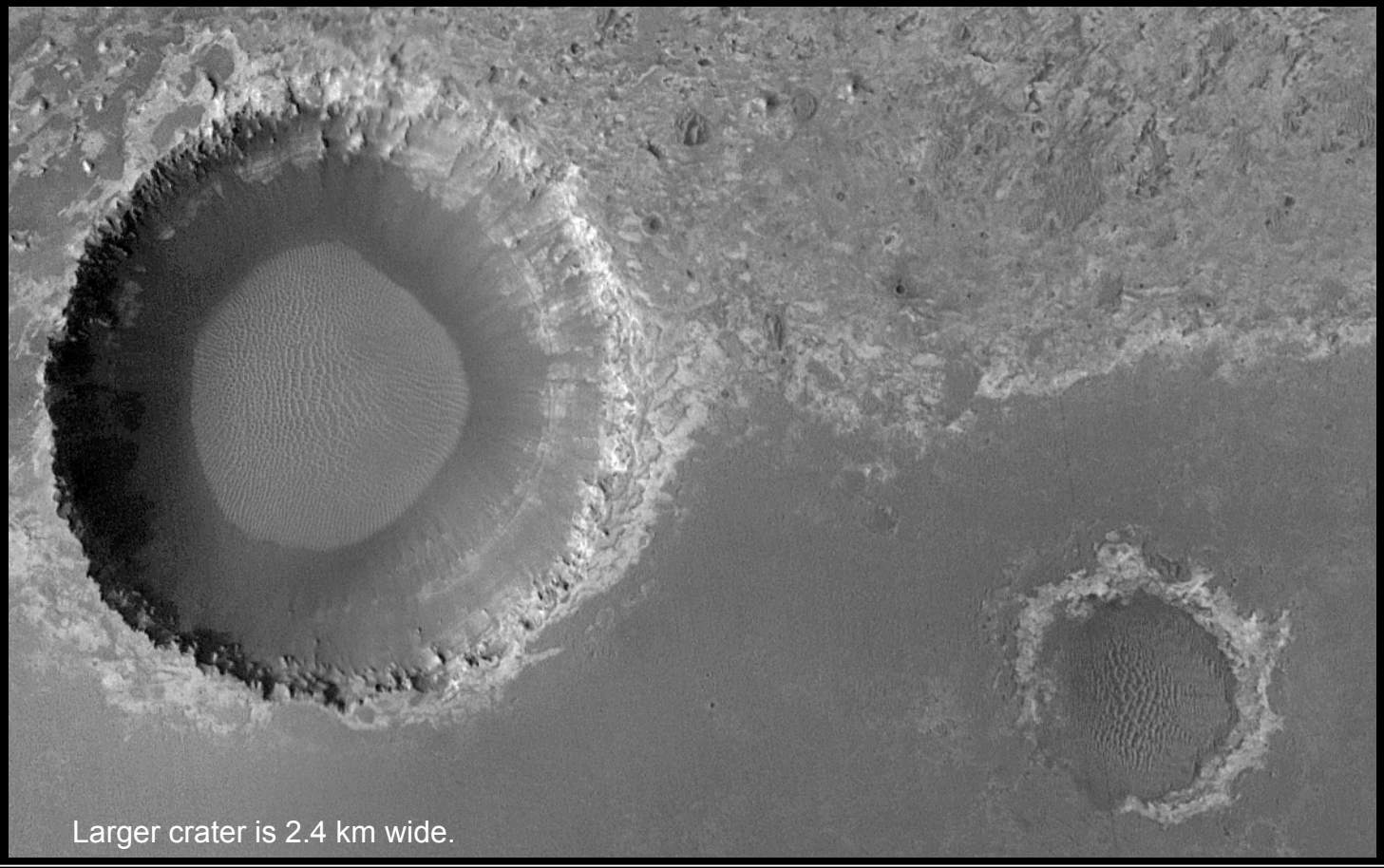
- This HiRISE sub-frame is representative of what the entire ellipse surface looks like.
- It is similar to areas encountered by MER-B around “Erebus”.
- In the ellipse, the MsL team would compare bedrock and regolith with observations from the MER-B site. Is the bedrock the same rock unit? Probably similar but lower in the strati-graphic section.



Sub-frame of HiRISE PSP_005647_1815, covering an area approximately 480 m wide, north is up.

(2) Examine Two Craters to the North

- After completing work inside the ellipse, the rover would be directed to go look at these two craters and the strata exposed in their walls (and in the material filling the smaller one).



Larger crater is 2.4 km wide.

Image from CTX mosaic noted previously

(3) Contact and Go Down Stratigraphic Section

- Then MsL would be directed to cross the boundary or contact between dark, regolith-covered plains and the light-toned rock to the north. The rover is now going downward in the regional stratigraphic section.

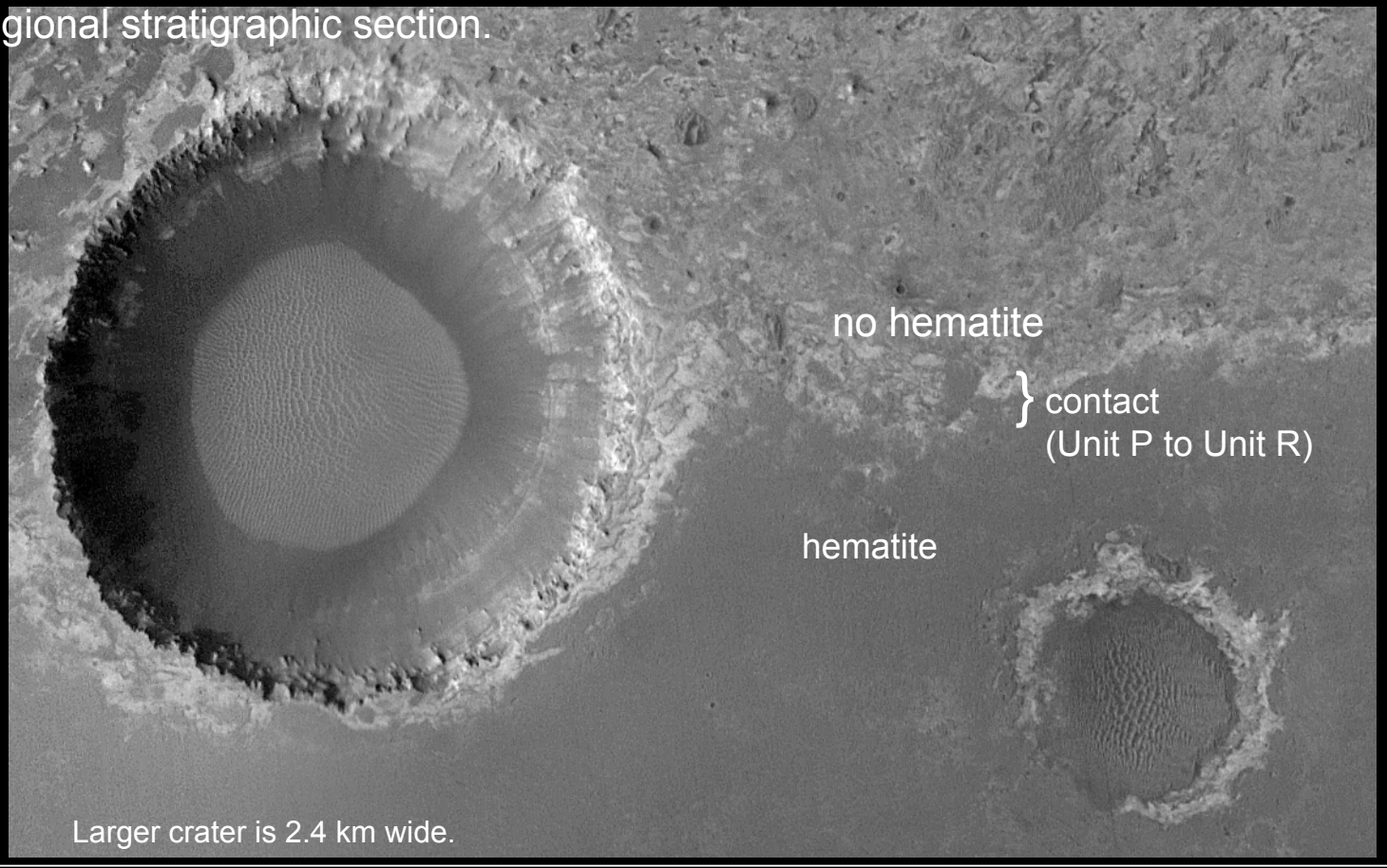


Image from CTX mosaic noted previously

(4) Stratigraphic Section and Rock Diversity

- MsL would explore the diversity presented by these relatively regolith-free rocks. Erosion of these rocks has not produced a lag of mm-size hematite spherules. And they are not covered by the mysterious regolith of mafic sand.

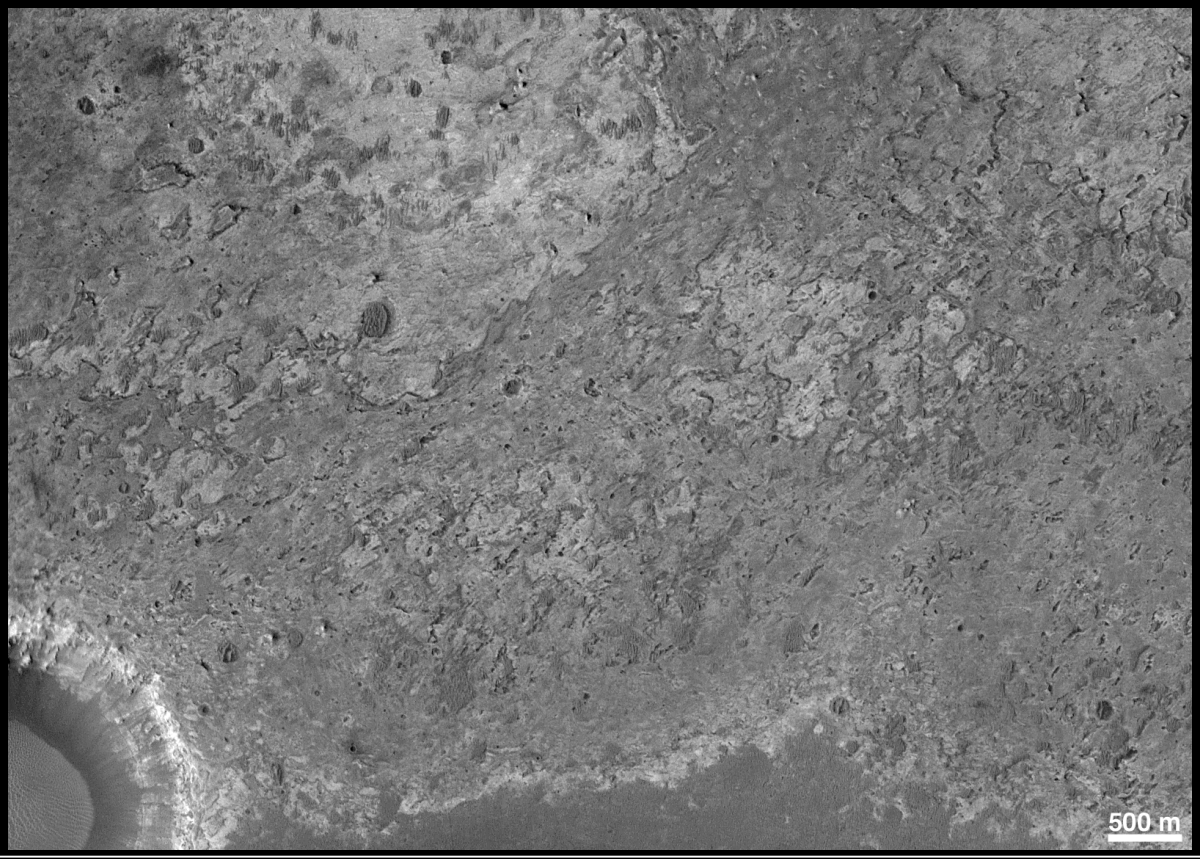


Image from CTX mosaic noted previously

(5) Examine Ridge-forming Material

- MsL would examine ridge-forming material—a rock material that is pervasive across Sinus Meridiani and not clearly understood. It may be in some places material that filled previous fluvia channels, in other places, perhaps it filled troughs formed by other means.

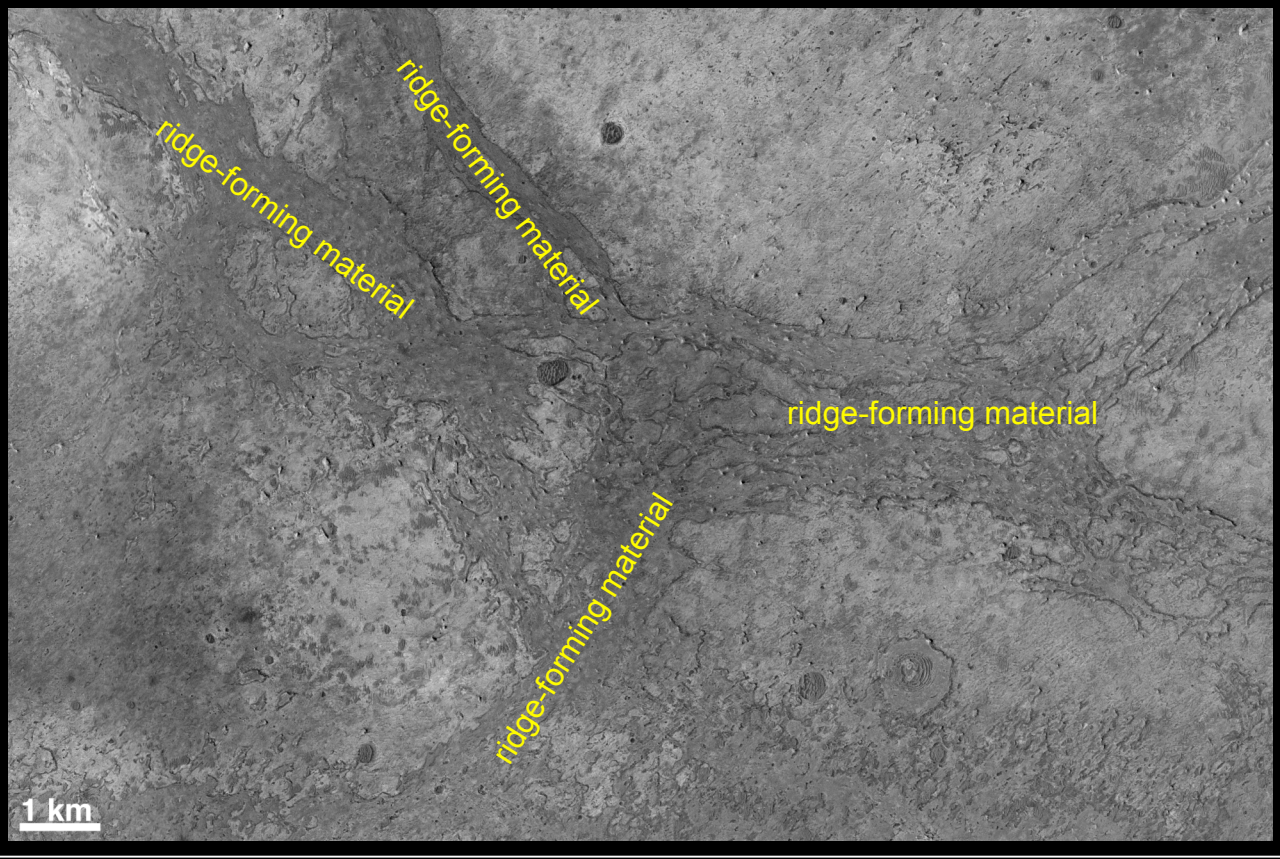
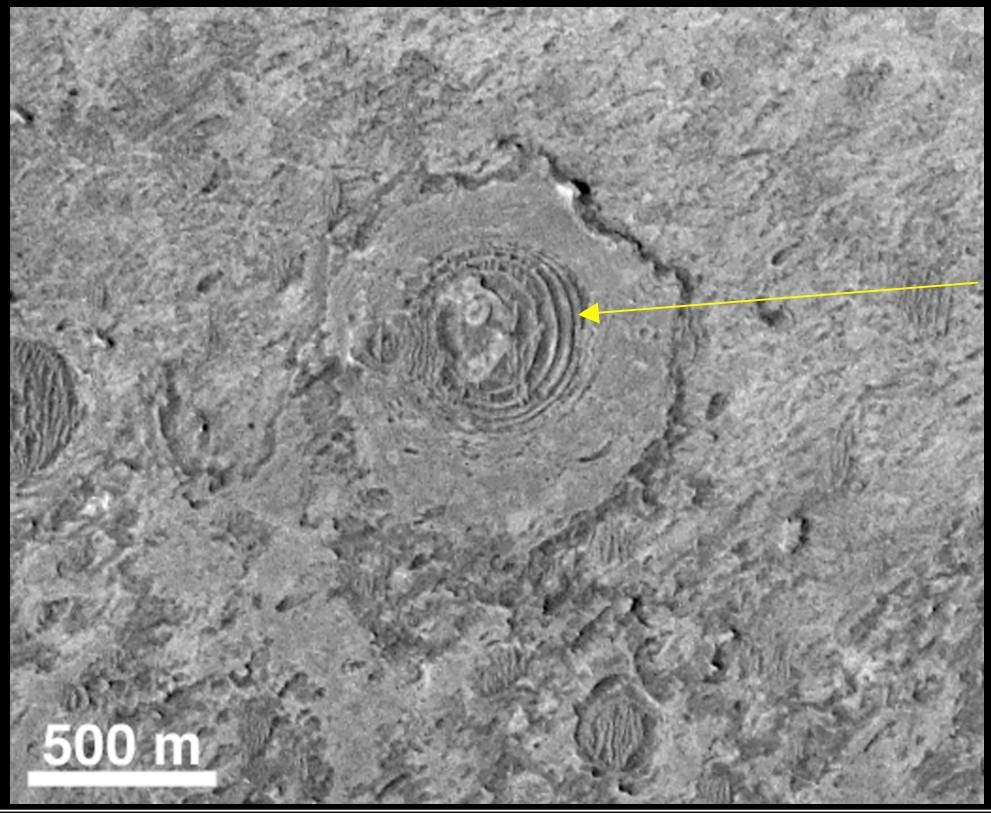


Image from CTX mosaic noted previously

(6) Examine Filled Crater with Different Strata

- A major objective at this landing site is to visit a small, filled impact crater that was filled, buried, and partially-exhumed. The bedding style in this crater is completely different from its surroundings. The crater was a different depositional environment. Test whether it was a small body of water, like a pond.



Why This Site Should be on the List of 5

- Probably safe for EDL. Like the rippled areas that MER-B encountered. For trafficability, there's lots of experience driving in this kind of terrain.
- Can fit a "safe haven"-sized landing ellipse, if necessary.
- Can test key hypotheses
  - in-ellipse opportunity to compare regolith and bedrock with MER-B site— Test whether observations at MER-B site apply to a larger fraction of the Meridiani region; are there cross-bedded eolian sandstones at this location?
  - Near-by go-to opportunity to explore boundary between hematite-bearing and non-hematite-bearing sedimentary rock— Test whether hematite is not present in rocks lower in the Meridiani stratigraphy, or whether the hematite concretions are simply smaller and do not form a lag.
  - go-to opportunity to visit ridge-forming material— Test whether these mysterious ridges in northern Meridiani are related to channel fill and fluvial processes.
  - go-to opportunity to visit small crater with repeated layering similar to what is seen to be a common theme on Mars— Test whether this was a subaqueous depositional setting.

MsL Landing Site Criteria

Major Questions/Criteria			N Meridiani Edgett/Malin Site 1
Ability to Assess Biological Potential w/MsL Payload			Yes, MsL payload can assess habitability here
	Evidence for Habitable Environments		Sedimentary rocks, possible subaqueous sedimentation, groundwater diagenesis
	Preservation of Biosignatures		[TBD]
Ability to Characterize			
	Geology/Geochemistry		Yes
	Context, Geologic Timescale		Yes; Late Noachian/Early Hesperian
	Context, Stratigraphic etc.		Yes; well understood stratigraphic placement relative to rocks at MER-B site (these rocks are lower/older than MER-B)
Accessibility			
	Accessed by Rover/Arm in Ellipse		Yes; some things to be studied occur within the ellipse
	Go To		Most things of high interest are outside/adjacent to ellipse
		Distance/trafficability	within 5 km of edge of ellipse; trafficability is like MER-B
		Dust obscuration	sharp albedo contrasts, no more dusty than MER-B site
Reduced Performance Thermal Constraints			site is equatorial, like MER-B, optimum location for MsL's anticipated thermal constraints
Surface Slope/Relief			
	2–10 km slope		[TBD] -- pretty darn flat
	1–2 km slope		[TBD] -- not likely to be a problem
	200–1000 m slope		[TBD] -- not likely to be a problem
	2–5 m slope		[TBD] -- can MsL land on bedform/ripply stuff that MER-B drove through?
	relief in HiRISE		rippled like MER-B site between "Erebus" and "Beagle"
Warning Track Slope			
	2–10 km slope		[TBD] -- pretty darn flat
Safe Haven?			possibly YES, but major science objectives are go-to
Rock Abundance			very low in terms of rocks that would be seen as hazards
	IRTM		< 5° (2° bins)
	TES		Likely very low, based on Nowicki and Christensen (2007)
	Rocks in HiRISE		very few rocks (HiRISE PSP_005647_1815)
Load-Bearing Surface			Yes, and it is known from MER-B how to navigate this stuff
Dust (DCI, albedo)			Like MER-B, very little dust; DCI ≥ 0.97 in Ruff and Christensen (2002) map
Cold Temperatures			Equatorial site. Optimum for year-round operations.
Trafficability			Like MER-B; better on go-to bedrock surfaces

— the end —